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ON THE ADVANTAGE
OF A
COLLECTION OF NUMBERS,
TO BE ENTITLED
THE CONSTANTS OF NATURE AND ART.

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My Dear Sir,

Amongst those works of science which are too large and too laborious for individual efforts, and are therefore fit objects to be undertaken by united academies, I wish to point out one which seems eminently necessary at the present time, and which would be of the greatest advantage to all classes of the scientific world.

I would propose that its title should be "*The Constants of Nature and of Art.*" It ought to contain all those facts which can be expressed by numbers in the various sciences and arts. A better idea will be formed by giving an outline of its proposed contents, and it may perhaps be useful to indicate the sources whence much of the information may be drawn.

These constants should consist of

1. All the constant quantities belonging to our system;—as distance of each planet,—period of revolution,—inclination of orbit, &c.—proportion of light received from sun,—force of gravity on surface of each.

These need not be further enumerated, as they have already been collected, and need only be copied.*

2. The atomic weights of bodies.

These may be taken from Berzelius, Thomson, or Turner.

The proportions of the elements of various compounds;—Acids with bases,—metals with oxygen, &c.

These may be taken from the best treatises on chemistry.

3. A list of the metals, with columns containing specific gravity,—Elasticity,—tenacity,—specific heat,—conducting power of heat,—conducting power of electricity,—melting point,—refractive power,—proportion of rays reflected out of 1000—at an incidence of 90°.

3. List of specific gravities of all bodies.

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* A work of this kind, embodying the results of science, has been projected for some time by M. Poggendorff of Berlin, and a specimen of it may be seen in his *Annalen*, xxi. p. 609.—J.

4 List of Refractive indices.

——— Dispersive indices.

——— Polarizing angles.

——— Angles formed by the axes of double refraction in crystals.

These may be extracted from the writings of Brewster, Mitscherlich, Herschel, Biot.

5. Number of known species of mammalia—birds—reptiles—fishes—mollusca—worms—crustacea—insects—zoophytes.

These classes might be further subdivided.

Additional columns should show how many of each are found in a fossil state, and the proportion between the fossils of existing and extinct species.

6. List of mammalia, containing columns expressing height—length—weight—weight of skeleton,—weight of each bone—its greatest length—its smallest circumference—its specific gravity—also the number of young at a birth—the number of pulsations per minute, whilst the animal is in repose—the number of inspirations in the same circumstances—period of blindness after birth—period of sucking—period of maturity—temperature,—average duration of life—proportion of males to females produced.

It would be desirable to select some bone for the unity of weight and perhaps of measure, and to give the proportion of all the other bones to this standard one. The numerical relations thus established might perhaps in some cases identify the sexes, or even the races of the human species, when only a few bones were found. It would also be highly interesting to compare the relative weight of the bones of persons employed in different trades, and of persons dying from certain constitutional diseases.

7. Of Man. Average weight at various periods of existence—height of do.—tables of mortality in various places—average duration of reigns of sovereigns,—proportions of the sexes born under various circumstances,—proportion of marriages under various circumstances,—quantity of air consumed per hour,—quantity of food necessary for daily support,—average proportion of sickness amongst working classes,—proportion of persons dying from different diseases.

Many of these facts may be found in the writings of Villermé, Quetelet, Bailly, Milne, &c.

8. Power of Man and Animals.

A man labouring ten hours per day will saw ( ) square feet of deal—ditto ( ) elm—ditto ( ) oak, &c.—ditto Portland stone—ditto Purbeck—Days labour in mowing, ploughing—&c. &c. every kind of labour—Raising water one foot high—horse do.—ox or cow do.—camel.

Power of steam engines in Cornwall.

Inclination of a road, both in degrees and number of feet, &c. or of a base on which carriages and horses can trot—walk,—on which horses cannot ascend—on which man cannot,—on which a cart cannot ascend.

9. Vegetable kingdom. Number of species known of monocotyledonous plants—number of species of dicotyledonous plants.

Number of species of the various natural groups.

Additional columns should show the number of species known in a fossil state, together with that of extinct fossil species.

Also average weight of vegetable produce of one acre in a year, when under different modes of cultivation,—hay—straw—wheat,—turnips,—and mangel wurzel,—potatoes—clover, &c. —produce of timber per acre.

10. Tables of the geographical distribution of animals and of plants,—of the average period of maturity and decay in various woods,—increase in weight annually at different periods,—weight of potass produced from each—proportion of heat produced by burning given weight.

11. Atmospheric phenomena. Weight of air above a square inch,—square foot,—an acre,—a square mile of the earth's surface, barometer at 30 in. Weight of oxygen, of nitrogen, of carbonicacid, above the same spaces, under the same circumstances.

Weight of water in vapour above ditto at various degrees of hygrometer. Depth of rain falling annually at various places, in inches,—columns for number of year's observation,—mean temperature,—mean height of barometer,—height of places above the sea,—drainage of surface-water for one, two, three, to ten inches, from each square of 100 feet side, each acre, or square mile, expressed in cubic feet, in gallons, and in hogsheads, water discharged per 1″ or 1′, per hour or per day, under various circumstances, as found by experiment,—velocity of rivers and torrents to carry stones of given weight.

12. Materials.—Height to which a column of any substance used in building may be carried before the lowest layer is crushed,—weight necessary to crush a cubic inch of each,—weight of cubic foot or cubic yard. Angles at which sand, gravel of various sized pebbles, snow, &c. support themselves. Strength necessary to pull asunder various woods,—bars of metal of various dimensions,—weight to break ropes and chains of various sizes,—column for weight to be safely borne by them,—friction under various circumstances,—resistance of fluids.

Weight of coal to burn 10 bushels of lime,—weight of ashes to burn 10,000 brick,—of coak to make ton of wrought iron,—tallow to make soap, &c.—and constants in all trades.

See Rennie, Tredgold, Prony, Eytelwein, Venturi, &c.

13. Velocities.—Arrow, musket-ball at several distances, cannon-ball, sound, telegraph, light,—birds.

Days journey. Man, horse, heavy waggon, stage-coach, mail-coach, camel, elephant, steam-carriage, steam-boat, balloon, greatest—average passage Liverpool to New York, &c.—of steam-boats, Dublin to Liverpool,—London to Edinburgh, &c.

14. Length of all rivers,—water discharged per hour.—Seas—proportion of water to land on globe,—area of all seas and lakes in square miles,—areas of all islands and peninsulas and continents,—heights of mountains,—depth of mines from surface,—quantity of water pumped out of mines.

Heights of above 7000 points in Europe may be found in Orographie, the third volume of the *Transactions of the Geographical Society of Paris.*

15. Population, extent in square miles, revenue, &c. of kingdoms,—births, deaths, marriages,—rate of increase,—population of great towns.

16. Buildings.—Height of all temples, pyramids, churches, towers, columns, &c. ;—also all single stones, as obelisks, and area covered by ditto,—area of all great public buildings. Dimensions of all columns in ancient temples,—lengths of all bridges,—of span of each arch, and height, also breadth of piers.

Such tables may be found in Wiebeking, *Architecture Civile*, in ——

17. Weights, measures, &c.—Factors and their logarithms to convert all money of every country into English pounds sterling.

Factors and their logarithms to convert weights of every country into English pounds avoirdupois.

———— ———— ———— ———— foot and ell measures in every country into English feet.

———— ———— ———— ———— measures of area, acres, &c. into English acres.

———— ———— ———— ———— liquid measures in every country into English imperial gallons.

These are already collected in several works of Löhmann of Dresden. See also *Universal Cambist.*

18. Tables of the frequency of occurrence of the various letters of the alphabet in different languages,—of the frequency of occurrence of the same letters at the beginnings or endings of words,—as the second or as the penultimate letters of words,—of the number of double letters occurring in different languages,—of the proportion of letters commencing sirnames amongst different nations.

See Quetelet, *Journal*, also *Dissertatio inauguralis Mathematica de literarum proportionibus*, F. J. Adelmann, Bruxelles, 1829.

19. Table of number of books in great public libraries at given dates,—number of students at various universities. Observatories of the world,—Transit, length of diameter of object-glass, maker,—Circle, length of telescope, aperture, diameter of divided circle, maker.

It would be desirable to give the date of the different eras by which time is computed, and perhaps tables of the reigns of sovereigns. Also a chronological table,—at least of scientific discoveries and their authors.

In the above enumeration, which is far from complete, some few of the uses of such a volume are noticed, others will present themselves to every reader, and probably many unexpected ones will arise. The facts being all expressed in numbers, if printed in a small type and well arranged, would not occupy a large space. Most of the constants mentioned in this list already exist, and the difficulty of collecting them would consist chiefly in a judicious selection of those which deserved the greatest confidence. The labour of extracting them from a great variety of volumes, and of reducing the weights and measures of other countries to our own, could be performed by clerks. To any individual who might attempt it, it must be a work of great labour and difficulty, and there are few persons possessing the varied knowledge which such a task implies whose talents might not be differently employed with more advantage to science. It is also certain that such an assemblage of facts, emanating from the collected judgment of many, would naturally command greater attention than if it were the produce of any single individual, however eminent.

It appears, then, that such a work is particularly fitted to be the production of a body of men of science, and I would appeal to the great academies of Europe whether they would not, by combining in one volume so vast a collection of facts, confer an important advantage upon science and upon all who are occupied with its pursuits. I would suggest that three of the academies of Europe, perhaps the Royal Society, the Institute of France, and the Academy of Berlin, should each publish at intervals of six years their own table of the CONSTANTS OF NATURE AND ART. Thus these publications might succeed each other at intervals of two years, and the man of science would always be able to refer to the most recent determinations of the constants he employs.

In order to execute the work, sub-committees of one or two persons must be appointed to each department, who should be directed in the first instance to prepare the outline of the constants they propose to insert. These views should then be considered and classed by a small committee, consisting of persons of general views and of various knowledge. The subcommittee should then collect and reduce to certain standards the constants committed to them, and the whole should be printed under the general superintendance of the committee, but each part should be specially revised by its own sub-committee.

A preface should be prepared, stating as shortly as possible the reasons for preferring or rejecting particular experiments or observations, and also, generally, the degree of accuracy the several subjects admit of. A good and concise system of references should be made to all the authorities for the numbers given. Whoever should undertake the first work of this kind would necessarily produce it imperfect; partly from omission, and partly from the many facts connected with natural history, which, although measured by number, have not yet been counted.

But this very deficiency furnishes an important argument in favour of the attempt. It would be desirable to insert the heads of many columns, although not a single number could be placed within them,—for they would thus point out many an unreaped field within our reach, which requires but the arm of the labourer to gather its produce into the granary of science.

It is, however, to be hoped that no fear of the imperfection of a first attempt will deter either any individual or any body of men from an immediate endeavour to produce a work fraught with so many advantages to knowledge. The task of revising it at each period of six years will be comparatively easy, and the discussions of new observations or additional experiments made during those intervals, will have an admirable effect in exciting the ambition of the inquirers, to bestow such care as shall claim for their results a place in the volume, in which the academy shall record the condensed expression of the knowledge of their age and nation.

If I should be successful in inducing any scientific academy to enter in the task, I am confident that many a weary hour, now wasted in the search for existing knowledge, will be devoted to the creation of new, and that it will thus call into action a permanent cause of advancement towards truth, continually leading to the more accurate determination of established facts, and to the discovery and measurement of new ones.—I remain, my dear Sir, very sincerely yours,

C. BABBAGE.

DORSET STREET, MANCHESTER SQUARE,
22d Feb. 1832.

TO Dr BREWSTER.

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